Desk Copy

ECE 300
Fall Semester, 2007
Test #2

wlg Test A

Name wlg
Print (last, first)

Work the exam on the paper provided.

(1) You are given the circuit of Figure 1.
(a) Find the Thevenin equivalent circuit to the left of terminals a-b.
(b) Draw your Thevenin circuit using your V_{TH} and R_{TH}.

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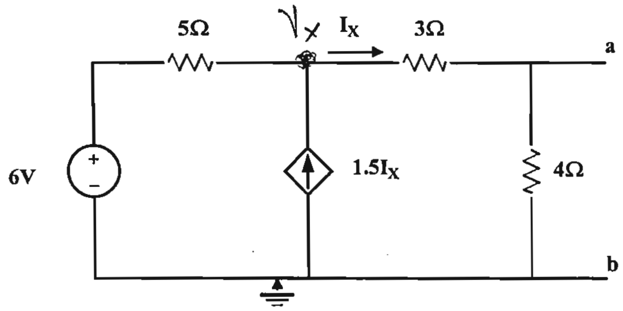


Figure 1: Circuit for problem 1.

For open circuit voltage,

$$\frac{V_x - 6}{5} + \frac{V_x}{7} - 1.5 I_x = 0$$

but $I_x = \frac{V_x}{7}$

so

$$35\left(\frac{V_x - 6}{5} + \frac{V_x}{7} - \frac{1.5 V_x}{7}\right) = 0$$

$$7V_x - 42 + 5V_x - 7.5V_x = 0$$

$$4.5 V_x = 42$$

$$V_x = 9.33\ V$$

$$V_{OC} = V_{TH} = \frac{9.33 \times 4}{3 + 4} = 5.33\ V$$

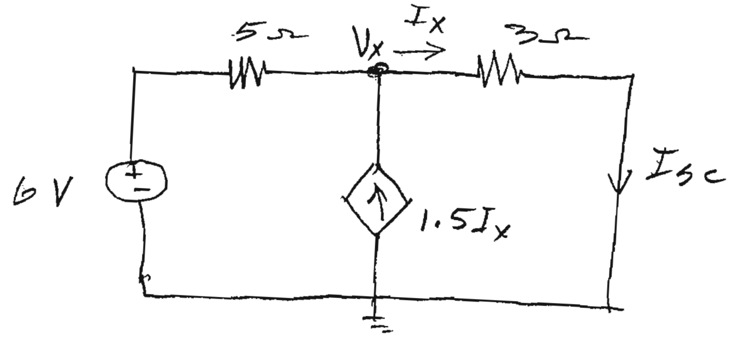
$\therefore$

$$V_{TH} = 5.33\ V$$

Test A
Problem 1

Now for I_{sc}

Shorting terminals a-b shorts out the 4 Ω resistor. We have



$$\left(\frac{V_x-6}{5} + \frac{V_x}{3} - 1.5I_x = 0\right) \quad ; \quad I_x = \frac{V_x}{3}$$

$$15\left(\frac{V_x-6}{5} + \frac{V_x}{3} - \frac{1.5V_x}{3}\right) = 0$$

$$3V_x - 18 + 5V_x - 7.5V_x = 0$$

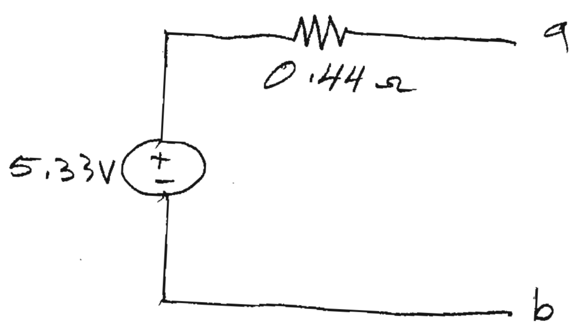
$$.5V_x = 18$$

$$V_x = 36$$

$$I_{sc} = I_N = \frac{V_x}{3} = 12A$$

$$R_{TH} = \frac{V_{OS}}{I_{sc}} = \frac{5.33}{12} = 0.44\,\Omega$$

(b)

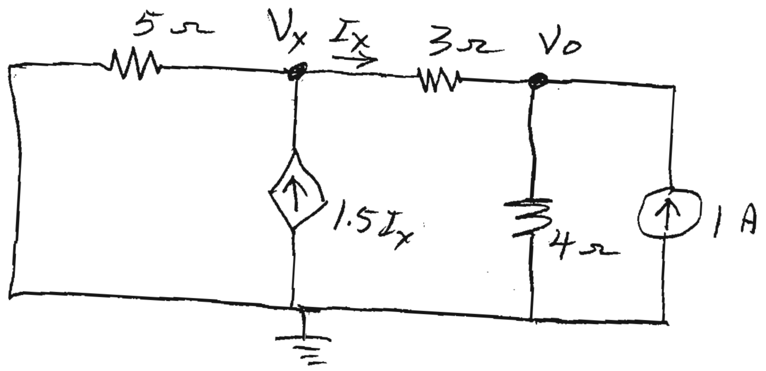


Thevenin Circuit

Test A

(1)

Alternate way to find R_{TH}.



At V_x

$$\frac{V_x}{5} + \frac{V_x - V_o}{3} - \frac{1.5\,(V_x - V_o)}{3} = 0$$

$$\frac{V_x}{5} - \frac{V_x}{6} + \frac{V_o}{6} = 0$$

$$6V_x - 5V_x + 5V_o = 0$$

$$\boxed{V_x + 5V_o = 0}$$

At V_o

$$12\left(\frac{V_o - V_x}{3} + \frac{V_o}{4} = 1\right)$$

$$4V_o - 4V_x + 3V_o = 12$$

$$\boxed{-4V_x + 7V_o = 12}$$

$$V_o = 0.444\ V$$

$$R_{TH} = \frac{V_o}{1}$$

$R_{TH} = 0.444\ \Omega$ check

(2) You are given the circuit of Figure 2. Find the value of R that will result in maximum power being delivered to this resistor.

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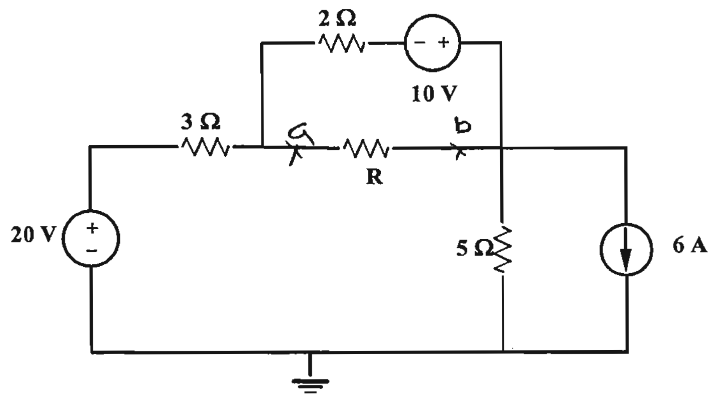
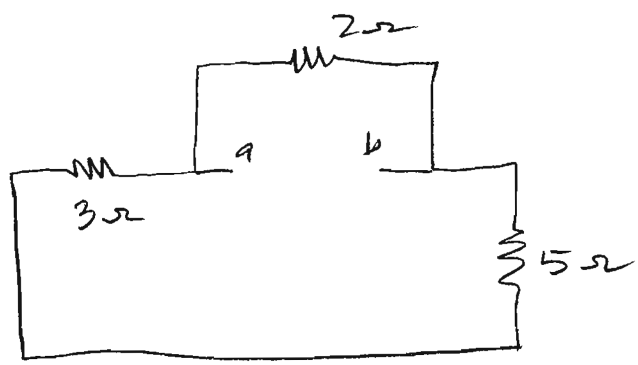


Figure 2: Circuit for problem 2.

Looking into a-b with independent sources deactivated, gives the following circuit.



$R = 2 \| 8 = \frac{16}{10} = 1.6\Omega$

So R for maximum power transfer is

$R = 1.6\Omega$

(3) You are given the circuit of Figure 3. Determine the relationship between V_o and I_o.
Circle the correct answer from the following list.

(a) $V_o = 24 - 5I_o$ (c) $V_o = 14 + 3I_o$ (e) $V_o = 36I_o$

(b) $V_o = 18I_o$ (d) $V_o = 24I_o$ (f) $V_o = 32I_o - 2$

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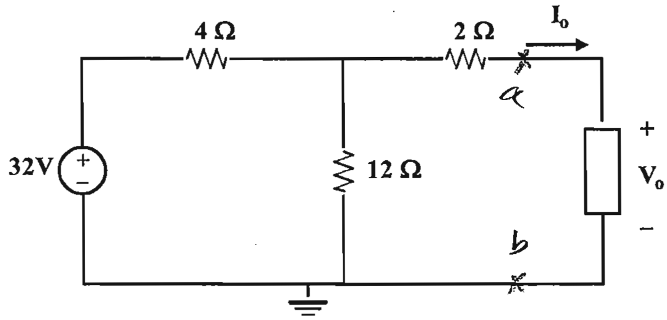
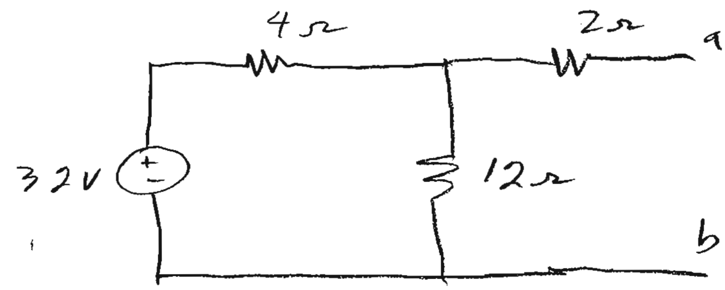


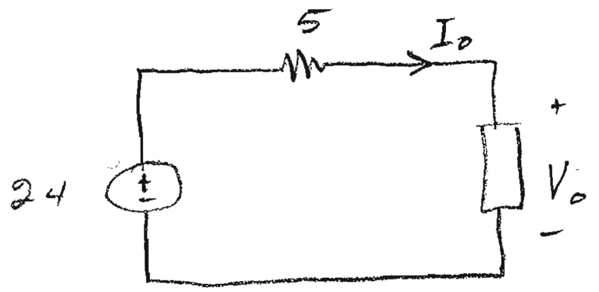
Figure 3: Circuit for problem 3.

Remove the load and find V_{TH}, R_{TH} looking into a-b



$V_{ab} = V_{TH} = \frac{32 \times 12}{12 + 4} = 24V$; $R_{TH} = (12 \| 4) + 2$

$R_{TH} = 3 + 2 = 5\Omega$



$V_o = 24 - 5I_o$

(4) You are given the circuit of Figure 4.

(a) Find the Norton equivalent circuit looking into terminals a-b.

(b) Draw the Norton equivalent circuit using your values of I_N and R_N.

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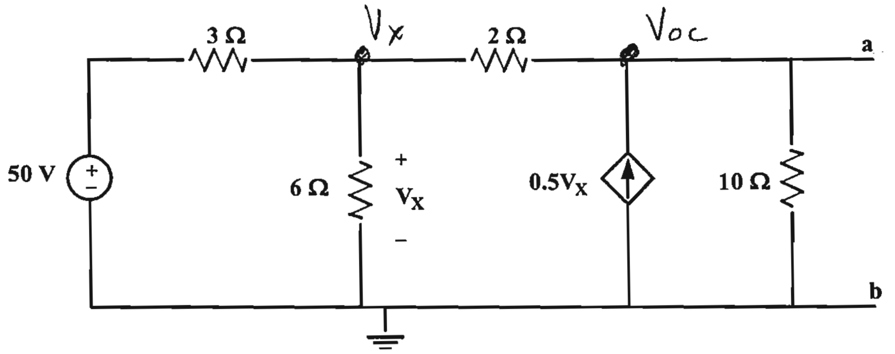


Figure 4: Circuit for problem 4.

Find V_{oc}: Use Nodal

At V_x:

$$6\left(\frac{V_x - 50}{3} + \frac{V_x}{6} + \frac{V_x - V_{oc}}{2} = 0\right)$$

$$2V_x - 100 + V_x + 3V_x - 3V_{oc} = 0$$

$$6V_x - 3V_{oc} = 100 \quad (1)$$

At V_{oc}:

$$10\left(\frac{V_{oc} - V_x}{2} + \frac{V_{oc}}{10} - 0.5V_x = 0\right)$$

$$5V_{oc} - 5V_x + V_{oc} - 5V_x = 0$$

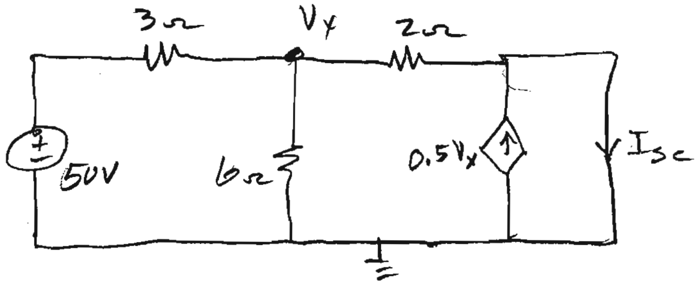
$$-10V_x + 6V_{oc} = 0 \quad (2)$$

From (1) & (2)

$$\begin{bmatrix} 6 & -3 \\ -10 & 6 \end{bmatrix}\begin{bmatrix} V_x \\ V_{oc} \end{bmatrix} = \begin{bmatrix} 100 \\ 0 \end{bmatrix}$$

$$V_o = V_{TH} = 166.67\ V$$

Now find I_{sc}



$$6\left(\frac{V_x - 50}{3} + \frac{V_x}{6} + \frac{V_x}{2} = 0\right)$$

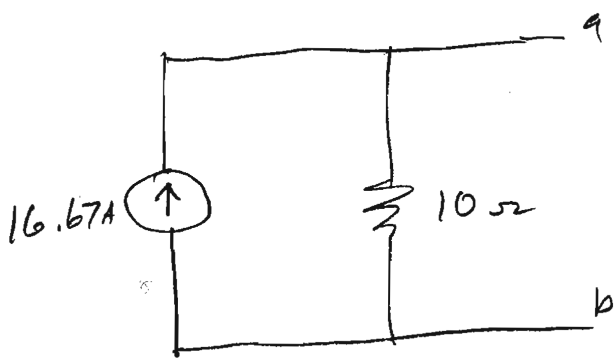
$$2V_x - 100 + V_x + 3V_x = 0$$

$$6V_x = 100$$

$$V_x = 16.67\,V$$

$$I_{sc} = \frac{V_x}{2} + .5V_x = \frac{50}{6} + \frac{50}{6} = \frac{100}{6} = 16.67A$$

$$R_{TH} = \frac{V_{oc}}{I_{sc}} = \frac{166.67}{16.67} = 10\Omega$$



Test A

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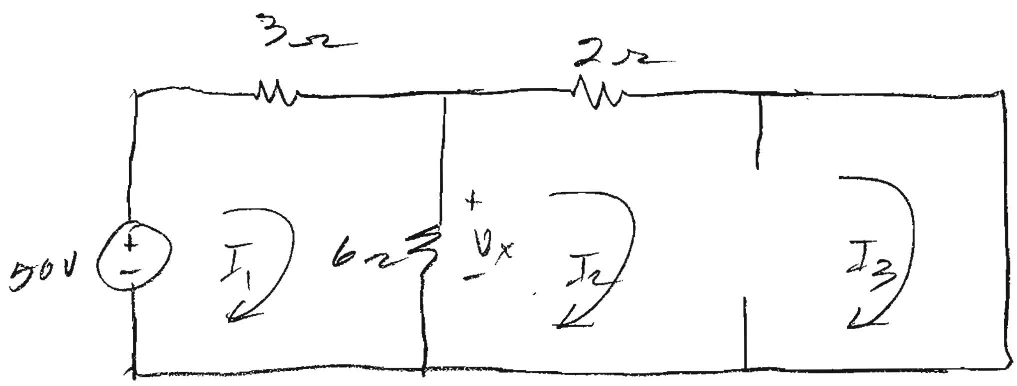

$$-50 + 9I_1 - 6I_2 + 0I_3 = 0$$

$$9I_1 - 6I_2 + 0I_3 = 50$$

$$-6I_1 + 8I_2 + 0I_3 = 0$$

$$0.5V_x = I_3 - I_2$$

$$0.5(6(I_1 - I_2)) = I_3 - I_2$$

$$3I_1 - 3I_2 - I_3 + I_2 = 0$$

$$3I_1 - 2I_2 - I_3 = 0$$

$$\begin{bmatrix} 9 & -6 & 0 \\ -6 & 8 & 0 \\ 3 & -2 & -1 \end{bmatrix} \begin{pmatrix} I_1 \\ I_2 \\ I_3 \end{pmatrix} = \begin{pmatrix} 50 \\ 0 \\ 0 \end{pmatrix}$$

$I_3 = I_{sc} = 16.67\ A$

(5) You are given the op amp circuit shown in Figure 5.
  (a) What is the rail-to-rail voltage of the circuit?
  (b) If $V_S = 1.5$ V, what is the value of V_O?

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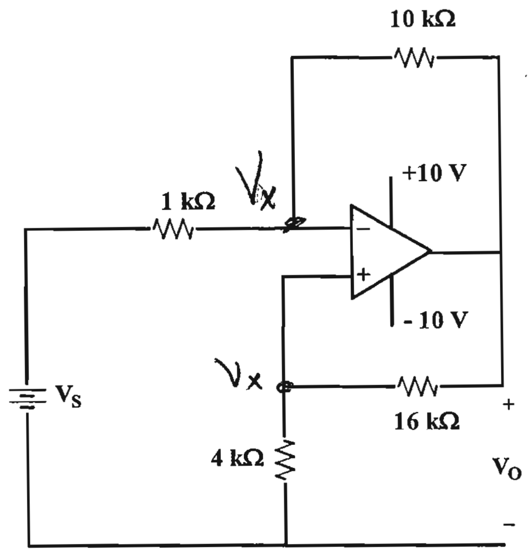

Figure 5: Circuit for problem 5.

(a) Rail to Rail: $\pm 10V$

At Vx

$$\frac{V_x - V_s}{1K} + \frac{V_x - V_o}{10K} = 0$$

but $V_x = \frac{V_o \times 4K}{4K + 16K} = 0.2 V_o$

$$\frac{0.2 V_o - V_s}{1} + \frac{0.2V_o - V_o}{10} = 0$$

$$2 V_o - 10 V_s + 0.2 V_o - V_o = 0$$

$$1.2 V_o = 10 V_s$$

$$V_o = 8.33 V_s \Big|_{V_s = 1.5V} = 12.5V$$ but limited to 10V

$$V_o = 10 V$$

(6) You are given the op amp circuit of Figure 6.

(a) Find the relationship for $\frac{V_o}{i_s}$ in terms of R.

(b) If R = 1 kΩ, what is the maximum value allowable for i_S in order not to saturate the op amp?

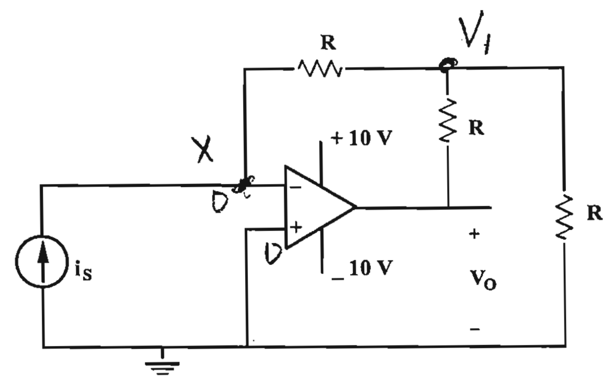

Figure 6: Circuit for problem 6.

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1a)

At X

$$\frac{0 - V_1}{R} = i_s \Rightarrow V_1 = -R i_s \quad (1)$$

At V_1

$$\frac{V_1 - 0}{R} + \frac{V_1 - V_o}{R} + \frac{V_1}{R} = 0$$

$$V_o = 3 V_1$$

using (1)

$$\boxed{V_o = -3 R i_s}$$

(b)

$$V_o = -3 R i_s \Big|_{R = 1k} = -3k\, i_s$$

$$\boxed{i_s = \pm \frac{10}{3k} = \pm 3.33\ mA}$$